

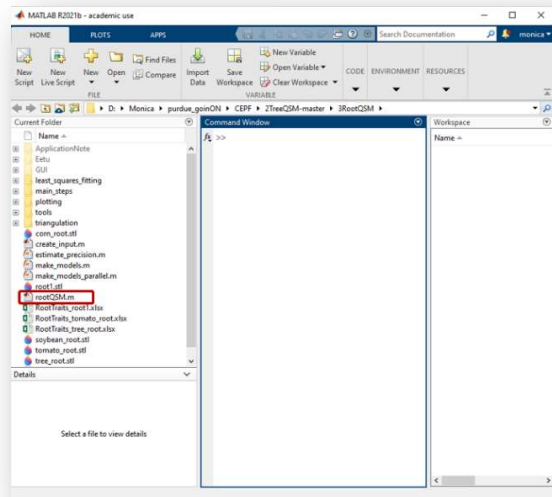
# 4DROOT SOFTWARE

## INSTALL FROM MATLAB:

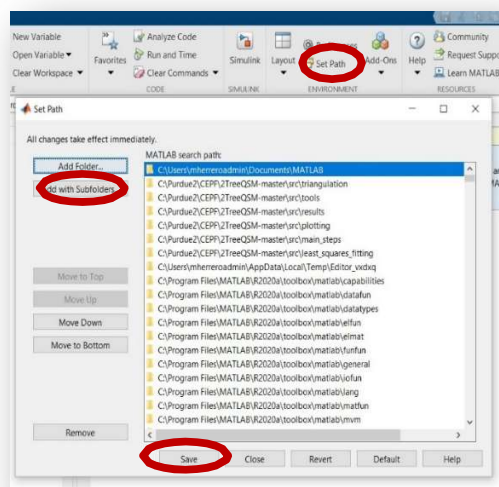
- COMPUTER VISION TOOLBOX
- PARTIAL DIFFERENTIAL EQUATION
- STATISTICS AND MACHINE LEARNING TOOLBOX

## INSTRUCTIONS: CODE FOR MODELING THE ROOTS

1. Download 4DRoot
2. Start MATLAB 2017 or newer and set the main path to the root folder, where rootQSM.m is located (from 4DRoot).

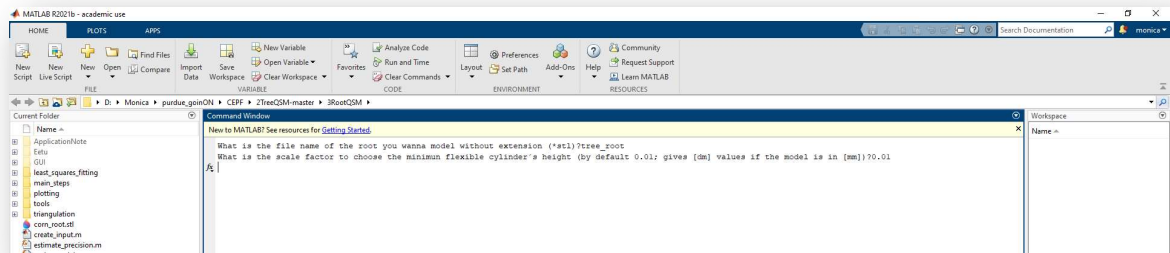


3. Use Set Path -> Add with Subfolders -> Open -> Save -> Close to add the subfolders, where all the code of the software is, to the paths of MATLAB.

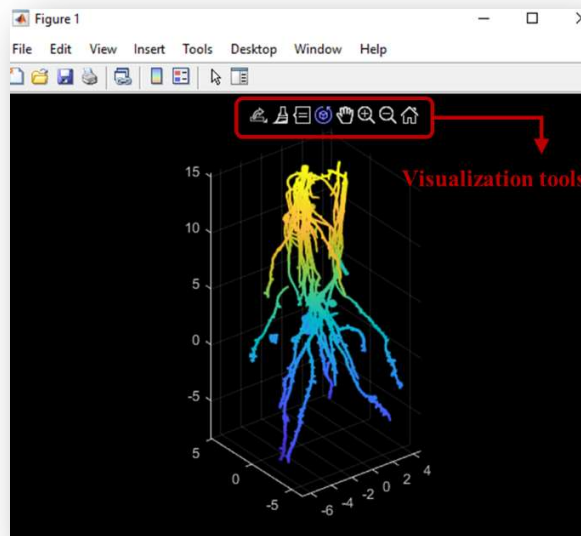


#### 4. Run rootQSM.m:

4.1. Inputs: 3D scan of the root in \*.stl format, scale factor to reconstruct the cylindrical fitting (0.01 by default) and desire to view the 3Dscan.

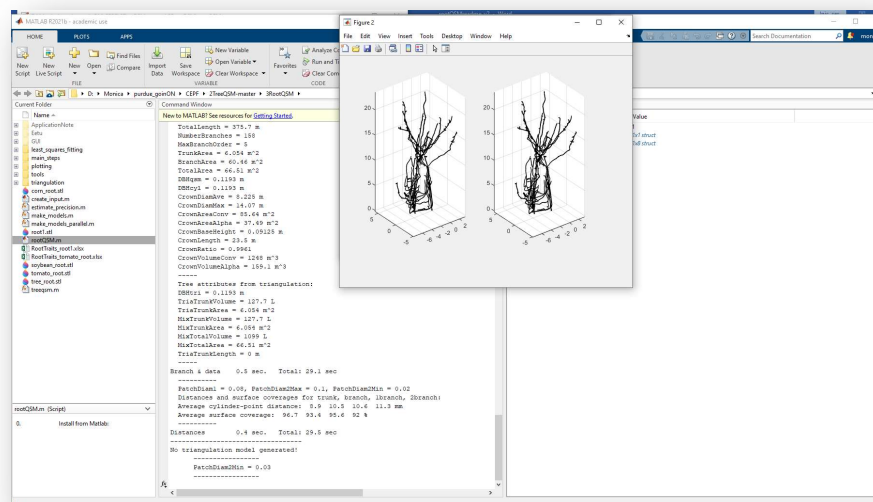


4.2. Visualization of the 3D scan as an option. Visualization tools are included.



After the visualization, the process is paused. To continue, press any key.

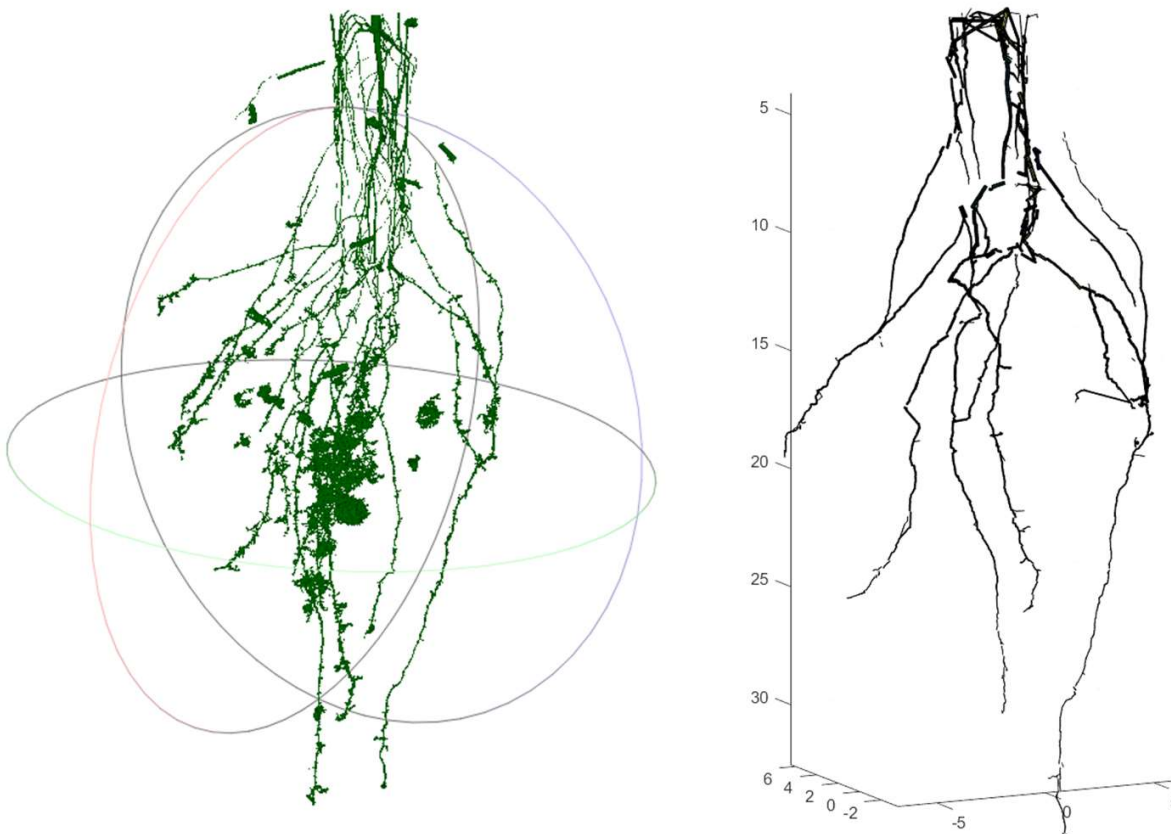
4.3. Numerical and graphic results of each approximation of the cylindrical model (upside down) when 3D Root is running.



4.4. Output: Phenotypic root traits and their distribution are extracted to an excel file with several sheets.

TRAITS	Value
TotalVolume*10 <sup>-3</sup> (dm <sup>3</sup> )	169.5274274
PrimaryRootVolume*10 <sup>-3</sup> (dm <sup>3</sup> )	120.747123
LateralRootVolume*10 <sup>-3</sup> (dm <sup>3</sup> )	48.5497052
TotalRootLength(dm)	6.81144934
TotalLength(dm)	65.5259713
PrimaryRootLength(dm)	7.15464225
LateralRootLength(dm)	58.3765594
NumberOfRamifications	28
Max.Ramif.Order	3
TotalArea(dm <sup>2</sup> )	7.03940643
PrimaryRootArea(dm <sup>2</sup> )	2.814337703
LateralRootArea(dm <sup>2</sup> )	4.22487466
CrownDiam(dm)	3.338427782
CrownMaxConeHalf(dm)	6.911247993
CrownAreaConeHalf(dm <sup>2</sup> )	9.68122229
CrownAreaAlphaShape(dm <sup>2</sup> )	5.780741892
CrownAreaLength(dm)	6.34651325
CrownLength(dm)	6.46612903
CrownRatio	0.349342046
CrownVolumeCone*10 <sup>-3</sup> (dm <sup>3</sup> )	93.9447
CrownVolumeAlpha*10 <sup>-3</sup> (dm <sup>3</sup> )	2.1892756
Location x	0.183279526
Location y	0.981759965
Location z	-2.965231895

**\*Noise removal:** noise from the segmentation between soil and root can be removed by 4DRoot by choosing an appropriated *scale factor* (left: 3D scan from a root, right: QSM from the root).



CITE:

1. Raunonen P, Kaasalainen M, Åkerblom M, Kaasalainen S, Kaartinen H, Vastaranta M, et al. Fast automatic precision tree models from terrestrial laser scanner data. *Remote Sens.* 2013;5(2):491–520.
2. Herrero-Huerta, M., Meline, V., Iyer-Pascuzzi, A. S., Souza, A. M., Tuinstra, M. R., & Yang, Y. (2021). 4D Structural root architecture modeling from digital twins by X-Ray Computed Tomography. *Plant Methods*, 17(1), 1-12.